An Overview of Single Hospital Based Study on Industrial Related Accidental Injuries Needing Plastic Surgical Solutions

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Abstract: Industrial accidents are the major cause of industrial injuries. In 1956, a WHO group defined an accident as "an unpremeditated event resulting in recognizable damage. Causes of industrial injuries are classified as injury due to mechanical failure, injury due to defective material, injury due to electronic failure and injury due to faulty design of equipment and injury due to environmental condition. General Principles of managing industrial related injuries are: Elimination/Substitution, Engineering Control, Administrative Controls, Work Practice Controls, Personal Protective Equipment PPE.

However every year throughout the world there are many industrial accidents and the world is paying heavily for that (i.e., for accidents and injuries) in terms of both human suffering and huge economic loss. A proper health care system should, therefore, be provided for control and prevention of industrial accidents among workers during their working period. Hence, in developing an efficient health care system, proper information on the status of occupational accidents/injuries in the industry are prime factors to be gathered.

Keywords: Industry, Injuries, Reconstruction.

1. INTRODUCTION

Industrial accidents are the major cause of industrial injuries. In 1956, a WHO group defined an accident as "an unpremeditated event resulting in recognizable damage" [1]. According to another definition an accident is an "occurrence in a sequence of events [which] usually produces unintended injury, death or property damage". On the other hand industrial injury can be defined as "the result of unsafe acts and unsafe working condition while working in an industrial working environment. Causes of industrial injuries are classified as injury due to mechanical failure, injury due to defective material, injury due to electronic failure and injury due to faulty design of equipment and injury due to environmental condition [2].

However every year throughout the world there are many industrial accidents and the world is paying heavily for that (i.e., for accidents and injuries) in terms of both human suffering and huge economic loss.

A proper health care system should, therefore, be provided for control and prevention of industrial accidents among workers during their working period [3]. Hence, in developing an efficient health care system, proper information on the status of occupational accidents/injuries in the industry are prime factors to be gathered.

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Epidemiology

Occupational injuries make an important contribution to the global burden of disease. Worldwide yearly more than 250 million workplace nonfatal injuries and 300000 fatal injuries take place [4].

Occupational injuries represent a significant public health problem in developing nations, such as India. In India work related injuries contribute to 2% of total deaths in a year.

Industrial Injuries are Categorized into Following Types

1. Mechanical injuries

2. Chemical injuries

3. Electrical injuries

Distribution of Injured Workers by Type of Hazard mechanical and chemical hazards caused 69.7% and 27.90% of total injuries respectively; whereas only 2.33% of the total number of injuries will occur due to electrical hazards [5].

Mechanical Injuries

• **Cutting and Tearing (Figure 1):** The seriousness of cutting and tearing the skin by a sharp edge depends on how much damage is done to the skin, muscles, tendons vessels, nerves and bones.

E-ISSN: 2414-2093/16

Figure 1: Cut lacerated wound over forearm.

• **Shearing:** Power driven shears for severing paper, metal, plastic and composite materials are widely used in manufacturing. Such machines cause amputation of fingers, hands and other parts of body.

• **Crushing (Figure 2):** Injuries from crushing typically occur when a part of the body is caught between two hard surfaces that progressively move together thereby crushing anything between them.

Figure 2: Mechanical crush injury right hand.

Skin and soft Tissue Injuries

The prevalence and acute nature of soft tissue injuries to hand, require complete evaluation and treatment.

• **Time Considerations:** Certain types of injuries require rapid response to prevent unfavourable outcomes. The following injuries require immediate treatment after diagnosis:

- Vascular injuries that cause heamorrhage
- Vascular injuries that compromise perfusion
- Compartment syndromes
- Amputations with potential for replantation

• **Lacerations:** Skin wounds of the hand must be handled with a methodical and thorough approach to optimize outcome and minimize morbidity. After the initial examination and a decision regarding need for radiologic studies, anesthetize the hand wound with lidocaine. Next, irrigate the wound profusely using clean or sterile water under pressure. Drape the wound and examine it carefully under proper lighting, Search vigorously for foreign bodies or evidence of tendon injuries.

To achieve haemostasis during wound exploration, fasten a sterile Penrose drain to the base of a digit. Inflate a blood pressure cuff to over 200 mm Hg, then clamp the tube to achieve good haemostasis. Total tourniquet time should no exceed 2 hours [6]. Close the skin wound with a single layer of simple or horizontal mattress sutures.

Tendon Injuries

Mainly divided into

1. Extensor Tendon Injuries: Partial tendon injuries (< 40-50% of the tendon width) usually do not require repair. They should be splinted and follow-up arranged with a hand surgeon.

Complete extensor tendon injuries can be repaired using 4.0 non-absorbable suture material and a figure **8** or modified Kessler suture, with the knot buried on the palmar aspect of the tendon. However, this procedure does not need to be performed urgently, and closure of the skin, splinting of the hand, and referral to a hand surgeon for delayed repair often is the best option.

The hand should be splinted in 30° of extension at the wrist with the MCP in a neutral position.

2. Flexor Tendon Injuries: Restoration of a smooth gliding function is essential to future normal use of hand. For this reason, primary repair should never be attempted in the ED.

Repair should be done by a qualified hand surgeon in an operating room equipped for microsurgery.

Vascular Injuries

Types of Vascular Injury

- Contusion
- Puncture

- Laceration
- Transection

Clinical Features

- Depends on site, mechanism and extent of injury
- Signs classically divided into 'hard' and 'soft' sign

Hard Signs of Vascular Injury

- Absent pulses
- Bruit or palpable thrill
- Active haemorrhage
- Expanding haematoma
- Distal ischemia

Soft Signs of Vascular Injury

- Haematoma
- History of haemorrhage at seen of accident
- Unexplained hypotension
- Peripheral nerve deficit

Investigation

Hard signs often require urgent surgical exploration without prior investigation.

- Arteriography should be considered:

– To confirm extent of injury in stable

– To confirm extent of injury in stable patient with equivocal signs

– To exclude injury in patient without signs but strong suspicion of vascular injury

Nerve Injury

Nerve injuries are classified basically into following types.

- Seddon Classification

1. Neurapraxia:

Same as Sunderland 1st degree, "focal nerve compression"

Nerve contusion leading to reversible conduction block without Wallerian degeneration

Histopathology shows focal demyelination of the axon sheath (all structures remain intact), usually caused by local ischemia prognosis recovery prognosis is excellent

2. Axonotmesis:

– Same as Sunderland 2nd degree

– Axon and myelin sheath disruption leads to conduction leads to conduction block with Wallerian degeneration

– Endoneurium remains intact

– Fibrillations and positive sharp waves on EMG

3. Neurotmesis:

- Complete nerve division with disruption of endoneurium

- Prognosis -no recovery unless surgical repair performed

Bone Injuries

1. Dislocations and fractures

– Distal interphalangeal joints

 Radiographic studies are indicated to rule out fractures.

 Examine the joint thoroughly after reduction. Then immobilize the finger with an aluminum splint. If the joint is irreducible, consultation with a hand surgeon is required.

 Irrigation, debridement, bacterial prophylaxis, and wound closure are indicated for open wounds [7].

– Proximal interphalangeal joints

 Lateral and dorsal dislocations may be treated effectively with closed reduction. While maintaining traction, hyperextend the phalanx (for dorsal dislocations) and bring it back to its normal anatomic position.

 Thorough physical examination with active and passive range of motion is required after reduction. If the joint is stable with active and passive range of motion, 3 weeks of immobilization followed by physical therapy is indicated.

 Pain and stiffness are likely sequelae and the patient should be forewarned. However, long-term prognosis is good.

– Metacarpophalangeal joints

 The recommended treatment of complex and volar dislocations is a gentle compression dressing and urgent consultation with a hand surgeon because they are likely to require open reduction.

– Interphalangeal joint of the thumb

 Evaluation and treatment of thumb IP joint injuries are similar to those for the IP joints of the fingers.

 After reduction, the joint should be immobilized in 20° of flexion for 3 weeks.

– Metacarpophalangeal joint of the thumb

 Simple dislocations may be reduced following administration of a median nerve block.

Flex and abduct the MCP joint and apply longitudinal force to the base of the proximal phalanx. Also see Joint Reduction, Thumb Dislocation.

 Thorough examination is necessary after reduction. If the joint is stable, immobilization of the MCP joint in 20° of flexion for 3 weeks is indicated.

Electrical Burns

Electrical burns are classified as low voltage (<1000 volts) and high voltage injuries (>1000volts).

Low voltage burns are generally localized to area immediately surrounding the injury.

High voltage burns causes cutaneous burn with deep underlying tissue damage (Figure **3**). The burn injury has potential to cause three different components: the true electrical injury caused by current flow, an arc injury resulting from electrical arc generated as current passes from source to an object and flame injury caused by ignition of clothing and surroundings [8].

The Consequences of Electrical Burns are Severe

Physically, victims may suffer from chronic pain and scarring. Workers may also have difficulty re-integrating into the community, and may experience anxiety, depression, or other psychological symptoms. The social and economic costs may also be high. Workers' compensation pays only a portion of lost wages. Some workers may not be able to return to their pre injury job. Employers bear the costs associated with lost productivity, reduced competitiveness, employee rehiring and retraining, as well being subject to increases in workers' compensation premiums.

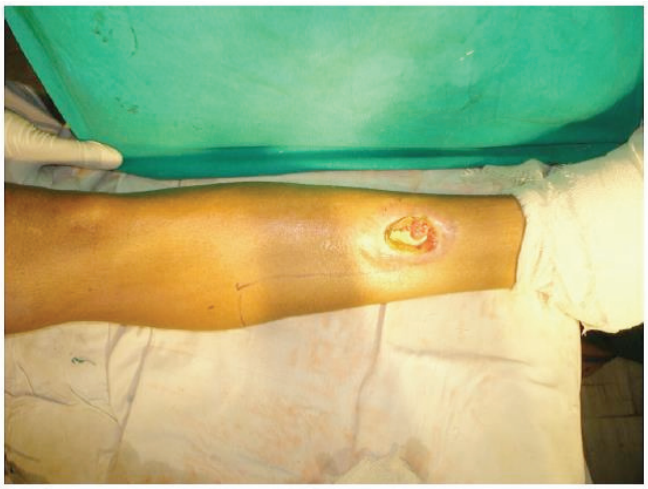

Figure 3: Electrical burns and exposed tibia.

Figure 4: Chemical burns.

Chemical Burns (Figure 4)

The following chemical groups commonly used in industry cause chemical burns: reducing agents such as sodium, potassium and lithium, used in metal cleansers and soldering processes; strong acids such as sulphuric, muriatic, tannic and hydrofluoric acid; bleaching agents; and strong bases such as lye. What Are Chemical "Burns"? Chemical burns are different from heat burns in two ways. They usually produce no heat, though the victim may feel a burning sensation. And they go on burning until every bit of the chemical is removed. This is because the chemical reacts with

body tissue to cause the burn. The longer the chemical remains on the body, the deeper the burn. Therefore, treating a chemical burn is a race with time-and the race leads to the shower or nearest available water source.

Specific Agents

Chromic acid: Contact with chromic acid, a powerful oxidizing agent used to clean other metals, will cause protein coagulation. The lethal dose for ingestion is between 5 and 10 g, and results in gastro- enteritis, followed by vertigo, muscle cramps, peripheral vascular collapse, and coma.

Dimethyl Sulfoxide (DMSO): This is a powerful organic solvent, with the ability to carry non-lipid soluble compounds quickly across cell membranes. It is used commonly in 'alternative medicine' as a relief for joint pain itself, but commonly is the vehicle for other agents. If implicated in a cutaneous injury, it is likely the dissolved sub- stance, rather than the DMSO itself causing injury.

Formic Acid: All patients injured by formic acid should be hospitalized due to multiple systemic effects of this metabolic poisoning agent. These problems include metabolic acidosis, intravascular haemolysis with hemoglobinuria, renal failure, pulmonary complications, and abdominal pain with necrotizing pancreatitis and vomiting [9].

Hydrocarbons: Prolonged contact with petroleum distillates results in dissolution of lipid cell membranes and resulting cell death [10]. These burns tend to be superficial and heal spontaneously [11]. Systemic toxicity includes respiratory depression and, when lead additives were present, systemic lead poisoning was common. The present epidemic of 'huffing' or inhaling volatile hydrocarbons has produced a syndrome of neurological damage as well.

Hydrochloric acid/muriatic acid: Muriatic acid is the commercial grade of concentrated hydrochloric acid. Once in contact with the skin, it denatures proteins into their chloride salts. Most significantly, hydrochloric acid fumes can cause inhalation injury with a sudden-onset pulmonary edema.

Hydrofluoric acid Hydrofluoric Acid (HF): is a commonly used acid with industrial applications. It is used as a cleaning agent in the petroleum industry and glass etching. It is also one of the strongest inorganic acids known. Hydrofluoric acid is particularly lethal due to its properties both as an acid and as a metabolic poison. The acid component causes coagulation necrosis and cellular death.

Nitric acid: A strong acid that can combine with organic proteins to produce organonitrates, which act as metabolic poisons.

Oxalic Acid: This is a potent metabolic poison that combines with calcium to limit its bioavailability. After exposure, serum calcium should be monitored closely, as well as signs of cardiac or respiratory muscle dysfunction: 0.5 g oxalic acid exposure or ingestion may be fatal.

2. AIMS AND OBJECTIVES

The objectives of this study are: -

1. To study the incidence of industrial injuries related to plastic surgery

2. To study the etiology of industrial injuries related to plastic surgery

3. To study the distribution of industrial injuries related to plastic surgery

4. To study the outcome

3. MATERIAL AND METHODS

The current study was conducted at the Gangamai Hospital, Sholapur. The study included retrospective analysis of the available PCRs (patient care records) was performed for all Industrial emergencies reported to plastic surgery department at our institute. From August 1st 2014 to July 31st 2016. The results of the study are based on all available patient care records for 256 cases. As a standard protocol, patient details including Name, age, sex, marital status, religion, place of residence, socioeconomic and educational status, mode of injury, time since injury and any treatment taken prior to coming to hospital, medical illness at present or in the past. The discharged patients were followed in the range 2 months to 1 year and they were properly instructed and advised for application of splints and perform physiotherapy exercises and massage with emollients to keep the skin moist and joints supple.

On the basis of analysis and observation, results were drawn and discussed and compared with other relevant literatures.

4. OBSERVATIONS AND RESULTS

The patients admitted in plastic surgery ward in from August 1st 2014 to July 31st 2016 were included in the study. Total 256 patients were admitted with industry related burns injury. The average admissions were 10.66 /month.

Majority of the victims of industrial emergencies were males 88% (224) and females represented 12% (32). Male: Female ratio of 7:1. Majority of the victims of Industrial emergencies were young adults of productive age group between 16-40 years, which include 63.3% males and 62.2% females. Children below 16 years were 1.56%, which include 0% female and 1.7% males. Adult age group 41-60 years represented 30.85%, which include 15.62% females and 29.91% males.

Trapped in machinery accounted for majority (50%) of industrial emergencies. Fall from height was second most cause of emergency (25%). Burns/fire (13%) and electrocution (10%) were the other leading causes of Industrial emergencies. Few cases of injury due to exposure to chemicals were reported (2%). Males were prone to trap or crush injuries (54%) in industrial emergencies whereas females were more exposed to burn or fire related injuries (38%). Injuries due to fall (31%) were second most cause of injuries in women where as men were more prone to fall (24%) followed by electrical injuries (11%).

Majority of industrial accidents occurred in industrial manufacturing units (60%) followed by chemical units (10%) and agricultural thrashing and reaping instruments (9%) and in the Jute/oil/paper/spinning/cotton/rice mills (9%). The other sites of industrial emergencies were steel plants (4%0, construction sites (2%), granite mines/quarries (2%) and fire crackers manufacturing units contributed to 2% emergencies.

Trapped in machinery accounted for majority (50%) or 128 patients. Out of 128 patients 33 patients (26%) were due to skin and soft tissue, 12 (9%) tendon injury, 8 (6%) were vascular injury, 5(4%) were nerve injury, 70% (54%) were combined injury.

Electrical injuries were 26 patients, 4 were managed conservatively, 6 patients underwent skin grafting and 6 patients underwent flaps (Figures **5-9**), 10 patients underwent amputation. Patients with trap /crush injuries were 28 patients, 78 (61%) patients were managed with repair with primary closure and 50 (39%) patients were managed with flap coverage. Out of all chemical injuries (2%), 60 % (3 pt) were managed with skin grafting and 40% (2 pt) were managed conservatively.

Figure 5: Cross finger flap.

5. DISCUSSION

In India the epidemiological data on the occupational injury and mortality is very scanty. Our analysis attempts to study the patterns and causative factors of

Figure 6: First dorsal metacarpal artery flap for volar defect thumb (Proximal phalanx).

Figure 7: (a). Littler flap for defect pulp of the thumb. **(b).** Littler flap for defect pulp of the thump.

Figure 8: Posterior interosseus artery flap for defect dorsum of hand.

industrial emergencies reported to department of plastic surgery at Gangamai hospital, Sholapur. Age and sex are the most important determinants of injuries. In the study majority of the accidents occurred among males i.e 224 (88%), with male to female ratio 7: 1. Similar findings were reported in a study conducted in Australia where Male: Female ratio was 6:1 [12]. One reason for the phenomena could be due to predominance of men in manufacturing industry in India. Majority of the victims of Industrial emergencies were young adults of productive age group between 16 to 40 years, which include 63.3% male and 62.2 % females as they are the bread winners of the family.

Figure 9: Reverse radial artery forearm flap.

In our study trapping/crushing in the machinery (50%) is a major cause of injury followed by fall of person from heights (25%). Similar findings were reported in a study conducted in Australia where crushing and piercing is major cause of injury in industries (33%) and the injuries related from fall is very less (9%). In a study conducted in Nicaragua, fall from height was a major cause of injury (30%) followed by blunt force trauma (28%) [13]. However the nature of injury is different with type of industry. Burns/ fire (13%) and electrocution (10%) were the other leading causes of industrial emergencies.

Males were more prone to trap or crush injuries (54%) in industrial emergencies were as females were more exposed to fire or burn related injuries (38%). Injuries due to fall (31%) was 2nd most common cause of injuries in women where as men more prone to fall (24%) followed by electrical injuries (11%).

Majority of industrial accidents occurred in upper extremities (35%) followed by multiple body injuries (24%) and lower extremities (23%).

Similar trends were observed in other studies conducted in Australia where especially upper limb is more exposed body part in industrial occupation [14].

Majority of industrial accidents occurred in industrial manufacturing units (60%) followed by chemical units (10%) and agricultural thrashing and reaping instruments (9%) and in the jute/oil/paper/spinning/cotton/rice mills (9%).

It is a clear indication of lack of safety measures in small scale and cottage industries.

There is need of implementation of appropriate safety measures in small scale /cottage industries.

6. CONCLUSIONS

The present study provides an overview of the most important aspects of industrial related emergencies in Gangamai hospital, Sholapur.

1. Industrial injuries average admissions per month were11.

2. In the study majority of the accidents occurred among males 88% (224) with male to female ratio 7: 1

3. Most industrial inju7ries in our study were due to trapping/crushing in the machinery (50%) followed by fall of person from heights (25%)

4. Majority of Industrial accidents occurred in Industrial manufacturing units (60%) followed by chemical units.

5. Majority of industrial accidents occurred in upper extremities (35%) followed by multiple body injuries (24%) and lower extremities (23%).

6. Majority of industrial emergencies are reported from cottage and small scale industries and chemical industries there is a need to conduct awareness programs in these sectors on accidents prevention.

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Received on 13-10-2016 Accepted on 03-11-2016 Published on 25-11-2016